ON PROBLEMATIC ORGANISMS, AND THE PRESERVATION OF ALGÆ AS FOSSILS.

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For many years past the subject of the animal or vegetable nature of a large class of fossil bodies has been a matter of discussion between two schools of geologists. One of these considers as fucoids or algæ a certain group of forms whose members do not present any organic appearance, but which in the early days of their study were made to do duty as plants, and which consequently still pose as such. The other class refuses to recognize the fossils as the remains of plants, and point out the analogy they present to worm trails, worm borings, animal tracks or marks of inorganic origin. These schools are represented on the fucoid-side by Saporta, Delgado and others, and on the opposite side by Nathorst, Dawson and others.

The attention of the present writer was first attracted to these fossil forms by their abundance in rocks of Lower Silurian age in the vicinity of Cincinnati, Ohio, the geologists there universally regarding them as plants. During the summer of 1884, while engaged in arranging the collections of the Cincinnati Society of Natural History many specimens were studied; and as supplementary thereto the markings made by various insect larvæ, shells, or by running water upon the mud-flats of the Little Miami river. The result of these studies was a paper on the "Fucoids of the Cincinnati Group," published in the Journal of the Cincinnati Society of Natural History, in October 1884 and January 1885. In this paper some of these so-called fucoids were referred to inorganic causes; many more to trails and burrows, and some few to graptolites. None were considered indubitable algæ. Some of the opinions in that paper require modification, but no additional information has caused the opinion that they are not the remains of algæ, to be changed.

Two subjects of primary importance need to be discussed before any detailed examination of these problematic organisms can be made. These are:—I.—Absence of organic or carbonaceous matter. II.—Probability of the preservation of algæ.

I.—Absence of organic or carbonaceous matter.

The absence of organic matter in the fossil bodies under consideration makes it difficult to decide in many cases what they really are. Their mode of occurrence is usually on the under side of the strata as objects in relief. They are mostly of indefinite and quite variable form, so it is scarcely possible to find any two alike in details. Not only are organic *form* and organic *substance* absent, but the beds in which the greater part of the bodies occur are strikingly deficient in organic remains of any other kind, and while these may be and are abundant in strata both above and below, the beds themselves are nearly barren of any but the problematic fossils.

The absence of carbonaceous matter has been considered by some a strong argument against the vegetable nature of the remains; while the presence of it has, conversely, been regarded as indicating an undoubted vegetable origin. But on the one hand we know of organisms, of unquestioned animal origin, in which not a trace of organic matter is left, the impression or cast alone remaining; and we likewise know of unquestioned vegetable remains which are also in the form of casts; but which are so perfectly preserved that even the delicate venation can be studied and described.

On the other hand there are forms of animal origin, like the graptolites, in which there is abundant evidence of the presence of carbonaceous matter, just as there is in true plants, and some of the graptolites were originally referred to the vegetable kingdom on this account. So that it can scarcely be considered that the presence of carbonaceous matter makes the organisms plants; or that its absence militates against their vegetable nature. But, when the absence of definite form, of carbonaceous matter, of other organisms in the same beds of rock, and their occurrence in demi-relief on the under side of the strata; when all these are taken into consideration, it can

scarcely be denied that the probabilities are strongly against, not alone the vegetable nature of the remains, but also against their being the actual remains of animal forms.

The disposition to regard certain branching fossils as plants, even when all carbonaceous material was absent, has been very general because it was for a long time supposed that worm burrows would not show any tendency to branch. But it is now well-known, as was pointed out by Dawson in 1873, and in much greater detail by Nathorst in 1881, that many worm burrows are habitually branched. This differs, however, materially from the dichotomy of true plants, although it has been confounded with it.

II.—Probabilities of the Preservation of Algæ.

Under the head of the probability of the preservation of algæ in a fossil state, much can be said. It will perhaps not be denied by any geologist, no matter to which one of the two schools he may belong, that algæ must have existed throughout all geological time, and that, too, often in the greatest abundance. This has been insisted upon by Salter (Memoirs of Geological Survey of Great Britain, vol. 3, 1866): by Lesquereux in his various publications (2nd Geological Survey of Pennsylvania, Report J; also Coal Flora, Report P; 13th Annual Report Geological Survey of Indiana; Annual Report Geological Survey of Pennsylvania for 1886, etc.), and by others. The presence of masses of graphite in the Laurentian rocks; of oil and gas in the Trenton and Devonian periods, to say nothing of the mere fact that myriads of animal forms could not have existed without the presence of algæ, is sufficient proof that they once existed. But the questions are: Have they been preserved? What are the chances of their preservation? Are all the forms that have been described as algæ, really such? If not; to what can they be referred? What is their origin? The answer to some of these questions is final as regards certain of the problematical organisms; but the answer to the first two general questions has certainly not yet been given.

The opinion held by many students is frequently biased by the expressed opinion of the first observer or describer of a

fossil. It has frequently happened, therefore, that when a form has been described originally as a plant, this identification has been accepted by subsequent workers, and only after many observations have been made and many treatises written, does the original opinion change. This is well shown in the case of *Scolithus.* Originally described as a plant, it was retained for many years in the vegetable kingdom, and only after numerous investigators had examined it, was it definitely referred to the animal world.

To secure an answer to the query, "what are the chances for the preservation of algæ as fossils?" It becomes necessary to observe what is going on in modern oceans and the ocean margins to-day. In all favorable localities seaweeds occur in wonderful profusion. Some varieties live only between tide marks; others only below tide and to a depth of 15 fathoms; others at still greater depths, the growth of these deeper water forms, however, being limited by the penetration of light, vegetation ceasing entirely at depths between 100 and 200 fathoms. These plants occasionally form great masses in the eddies caused by oceanic currents, and cover many square miles of surface. This is the case with the Sargasso sea in mid Atlantic: the sea of kelp off the Falkland islands, and that off the coast of Japan. Some species are tough and leathery, and have thick stems and long fronds, some of these reaching a length of 300 feet. Some are fine and feathery, branching so as to form innumerable minute divisions. Some are hardly more than masses of jelly; and some are covered with a calcareous coating and are thus more or less hard and horny. The last class, however, are not numerous. They are known commonly as *Nullipores.*

The structural characters of the algæ as a class, are strongly against their preservation under any sort of cover for any long period of time. The tissue is a mass of loosely united cells, often with scarcely more than sufficient coherence to hold together; and even in the tough and leathery varieties, the cells have little consistence, are all of one character, and retain their form for only a short period when buried. The late Prof. Leo Lesquereux studied the possibilities of preservation of algæ,

and he reached the conclusion that marine plants are only rarely preserved in a fossil state. He based his deductions of past conditions upon present ones; and he noted that algæ are at the present time scarcely ever found in any good state of preservation. "The difference," he says, "between the woody or vascular tissue of land plants and the cellular compound of the marine or fresh-water algæ, mere filaments glued together, or imbedded in vegetable mucus or gelatine, explains at once why the remains of fucoids are so rarely found petrified." Further he says: "Nowhere have I been able to find any trace of a deposit of sea-weeds preserved from decomposition under any kind of superposed materials, sand, clay, etc. And, nevertheless in some of the countries visited, the shores in many localities are strewn with immense heaps of those plants thrown out by the waves. Marine vegetables, though they may appear of hard, leathery texture like most of the common species of Fucus, soon disintegrate, and pass into a gelatinous, half-fluid matter, which penetrates the sand, so that the lowest strata of these heaps when exposed to atmospheric action, do not generally preserve traces of their organism for more than one year."

While Lesquereux thus announces his positive belief, Mr. G. F. Matthew says that while the algæ buried in *sand* leave no trace, "in clay the result is different. In the Till and Leda Clays of the Acadian coast, which have considerable antiquity, the writer has seen Polysiphonias and other delicate sea-weeds as well preserved as the ferns and Asterophyllites of the shales of the Carboniferous system."

It is generally acknowledged that organic remains are more likely to be preserved in an area of subsidence than in one that is stationary or rising. Sediment is rapidly accumulated in the first, and animals living in the vicinity are likely to be preserved. It is also probable that animals living on or near the bottom of the ocean have a better chance of being entombed than those floating in the water, so that a certain depth of water and a comparatively rapid accumulation of sediment seem to be two necessary adjuncts for the preservation of organisms in anything like abundance or perfection. The so-

called "Fucoids," and the problematical organisms in general are mostly found in strata whose appearance indicates disposition in shallow water. Now this is in just the position where algæ might be expected to occur, but it is also the place where the chances of preservation are fewest. This seems to be conclusively shown by the almost complete absence of true animal remains from strata where the problematical organisms are most abundant. While fossils occur both above and below this horizon, and frequently in the greatest abundance, the actual layers where "Fucoids" are found are notorious for their barrenness. The fragments which *are* found attest the abrading power of the water and we again see the small chance cellular organisms would have of being preserved, when calcareous bodies of animals are ground to fragments.

On the other hand it should be remembered that shallow flats, exposed, it may be, to the air twice a day, or even covered with a slight depth of water, are admirably situated to receive and retain impressions left by crawling animal forms. Rain drop impressions, too, could be preserved, as well as mud cracks and the excavations made by rills of water on a sloping shore. These have all occured. Rain drop impressions, sun cracked earth, rill marks on the shore, and the burrows or trails of worms and molluscs, are all known from various geological horizons. But true algæ in the older rocks are rare indeed; and the most of those described as such take their place among the much discussed problematic organisms. The probabilities that true algæ are included among the long list of species referred to as plants is almost infinitely small; while on the contrary the chances that what have been so considered are referable to tracks, trails or inorganic causes, are almost infinitely great. Nathorst has pointed out that an algæ in sinking to the bottom of the water, if sufficiently solid to be preserved, would not make a *depression* in the mud, but rather an *elevation*. In reality the depression is what is found in the top of the stratum, while the elevation or cast occurs on the bottom of the next overlying stratum of rock.